International Cooperation and Competition in Civilian Space Activities

Summary

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Foreword

The nature of global space activities has changed radically over the last decade. No longer are the United States and the Soviet Union the only countries capable of placing satellites into Earth orbit or sending interplanetary probes into deep space. Europe and Japan now have substantial space programs and have developed commercially competitive space systems. Several newly industrialized countries are well along in building their own space programs. In addition, the U.S. private sector has recently expanded its interest and investment in space technology. As this report makes clear, these changes have strong implications for the U.S. Government space program and for the U.S. private sector.

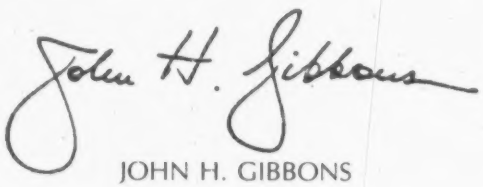
This summary presents the major findings of an assessment requested by the House Committee on Science and Technology and the Joint Economic Committee on international cooperation and competition in civilian space activities. The United States still enjoys a strong competitive position in most space technologies and in space science. There continues to be broad support for a long-term public commitment to civilian space activities. But precisely because of our achievements—and those of other space faring nations—the number of opportunities (and associated costs) that lie before us require a thoughtful articulation of space goals and objectives.* Such goals should reflect a broad public consensus, including, but not limited to, those with obvious stake holdings in the space program. Defining these goals may be essential if the United States hopes to maintain its position of leadership at a reasonable cost. The newly authorized National Commission on Space, which OTA proposed as one option in an earlier report *(Civilian Space Policy and Applications)*, could help to focus the national debate.

Maintaining a space program well-integrated with other national objectives will also require attention to the quantity and quality of cooperative international space projects. This report makes clear that the United States must cooperate in space in order to stay competitive.

In the course of this assessment OTA completed two technical memoranda, prepared at the request of congressional committees. *UNISPACE '82: A Context for Cooperation and Competition*, was requested by the House Committee on Science and Technology and the Joint Economic Committee. *Remote Sensing and the Private Sector: Issues for Discussion* was requested by the House Committee on Science and Technology and the House Committee on Government Operations. Some material in this report is discussed in more detail in the technical memoranda.

In undertaking this assessment, OTA sought the contributions of a wide spectrum of knowledgeable and interested individuals. Some provided information, others reviewed drafts of the report. OTA gratefully acknowledges their contributions of time and intellectual effort.

*For an initial suggested list of such goals and objectives, see *Civilian Space Stations* (Washington, DC: U.S. Congress. Office of Technology Assessment, OTA-STI-241, in press.)



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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by these advisory panel members. The views expressed in this OTA report, however, are the sole responsibility of the Office of Technology Assessment.

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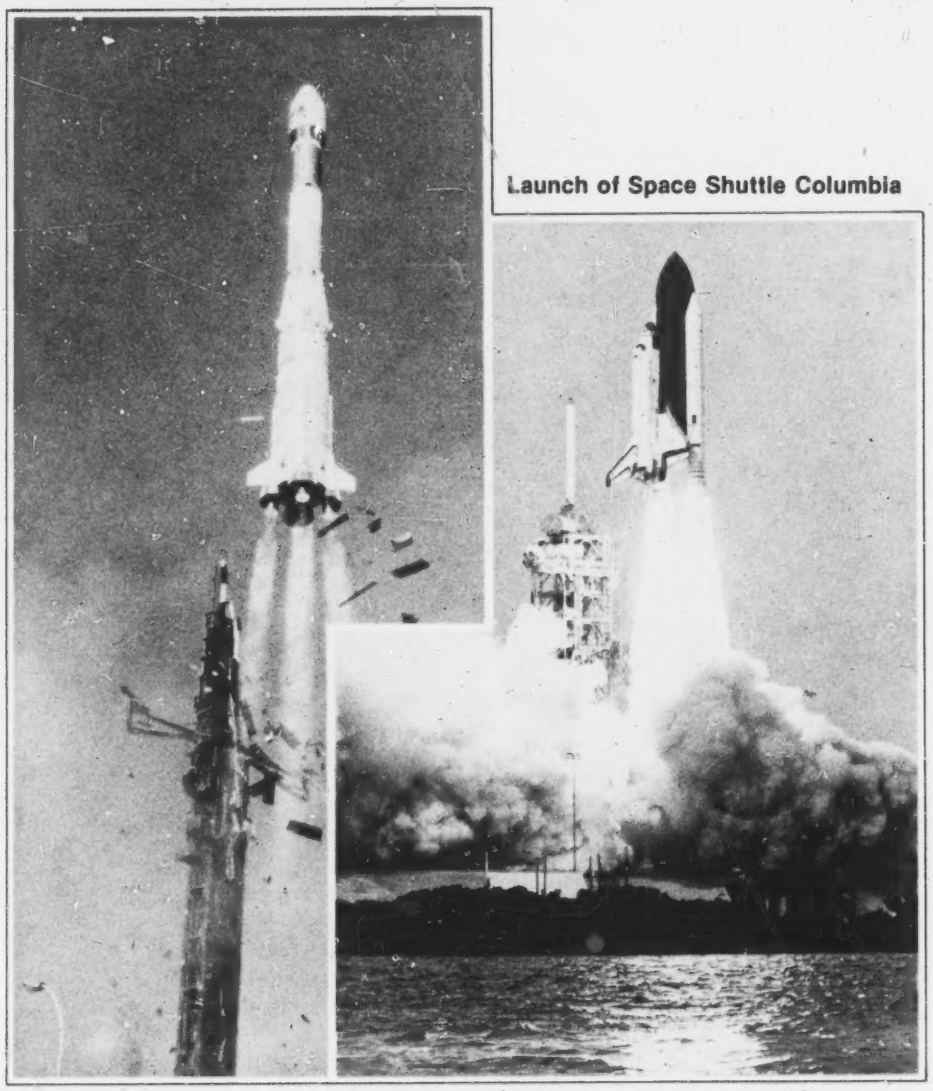

Photo credits: European Space Agency, complements of National Aeronautics and Space Administration

Launch of Ariane (left), developed by the European Space Agency and marketed by the French corporation Arianespace, S. A. Launch of Space Shuttle Columbia (right), Nov. 28, 1983, carrying the European-developed Spacelab

International Cooperation and Competition in Civilian Space Activities

OVERVIEW

The United States has lost its monopoly in Western space technology and operations; over the past decade, Europe and Japan have developed the means to compete as providers of space-related goods and services. At the same time, major U.S. firms have expanded their interest and investment in the commercial applications of the technologies of outer space. Both developments affect the ways that nations now cooperate in space. **Unfortunately, U.S. policies have not adapted fully to the effects of increased foreign competition, nor, outside of satellite telecommunications, has the United States developed ways to involve its private sector effectively in applications of space technology.** Moreover, it is less and less appropriate to make "space policy" in isolation from the broader agenda of domestic and international commerce and foreign affairs.

Alterations in the political, economic, and technical context of space activities raise **four major international concerns for Congress: the state of U.S. competitiveness in space technologies, the role of the U.S. private sector in space, the access of U.S. firms to international markets, and the efficacy of U.S. participation in international cooperative space projects and organizations.** Because of these concerns, and because of their interest in developing policies to enhance the overall scientific, technological, and economic strength of the United States, the House Committee on Science and Technology and the Joint Economic Committee requested this assessment.

The report assesses the state of international competition in civilian space activities, explores U.S. civilian objectives in space, and suggests alternative options for enhancing the overall U.S. position in space technologies and space science. It also investigates past, present, and projected international cooperative arrangements for space activities and examines their relationship to competition in space. In keeping with the international focus of this assessment, the report discusses the relationship between space policy and foreign policy. It analyzes domestic policy issues only insofar as they affect our ability to sell goods and services abroad or to cooperate effectively with other nations. It does not assess policies related to the military and intelligence space programs except to the extent that they affect international civilian activities in space.

CONTEXT

Emergence of International Competition

Although the U.S. civilian space program remains the benchmark by which other non-Communist nations judge the progress of their own space programs, **Japan and the Western European space powers (especially France) are now able to compete with the United States in supplying some space-related goods and services.** Other countries, notably the Soviet Union, Canada, India, Peoples Republic of China, and Brazil, produce space items but do not participate in the international export market. Most space-capable nations have sought to use their space assets as political instruments for cementing ties with friends and allies and for winning new friends and influence in the developing world.

Space-related international commerce is likely to increase in the next decade, but, except for satellite communications, will continue to be shaped more by the political, military, and economic interests of national governments than by market developments. In the satellite communications sector, which has become part of the larger telecommunications industry, technology-driven market developments are forcing governments to change their regulatory structures.

The emergence of foreign competition presents both a challenge and an opportunity to the United States. The European Space Agency (ESA), which pools the space interests and the financial and industrial resources of several European countries, is an important vehicle for developing European competitive ability in space-related commerce. Its largest single project, the Ariane expendable launch vehicle, built under French leadership, now competes directly with U.S. launch services. ESA's second largest project, the Spacelab, built under West German leadership, has increased European cooperation with the United States in activities involving humans in space. It has also assisted West Germany to gain important expertise in building space habitats, thereby helping to set the stage for possible later competition with the United States.

Outside of the ESA framework, **the French Government has established and promoted particular space businesses (launch services and remote sensing) that compete in the world market. West Germany, as well as France, and to a lesser extent, the United Kingdom and Italy, invest in space activities for more general purposes:** to conduct basic scientific research; to enhance the technological capabilities of national industries; to realize some of the technological and economic benefits of space applications; and to develop space-related equipment industries. European governments are developing their space-related industry behind protectionist barriers where buy-national government procurement is the rule. A number of European firms are now able to participate in international space markets.

Like the other space powers, Japan has assumed that a government space program will ultimately contribute to national economic well-being. It has not specifically identified space industries as "targeted" for special em-

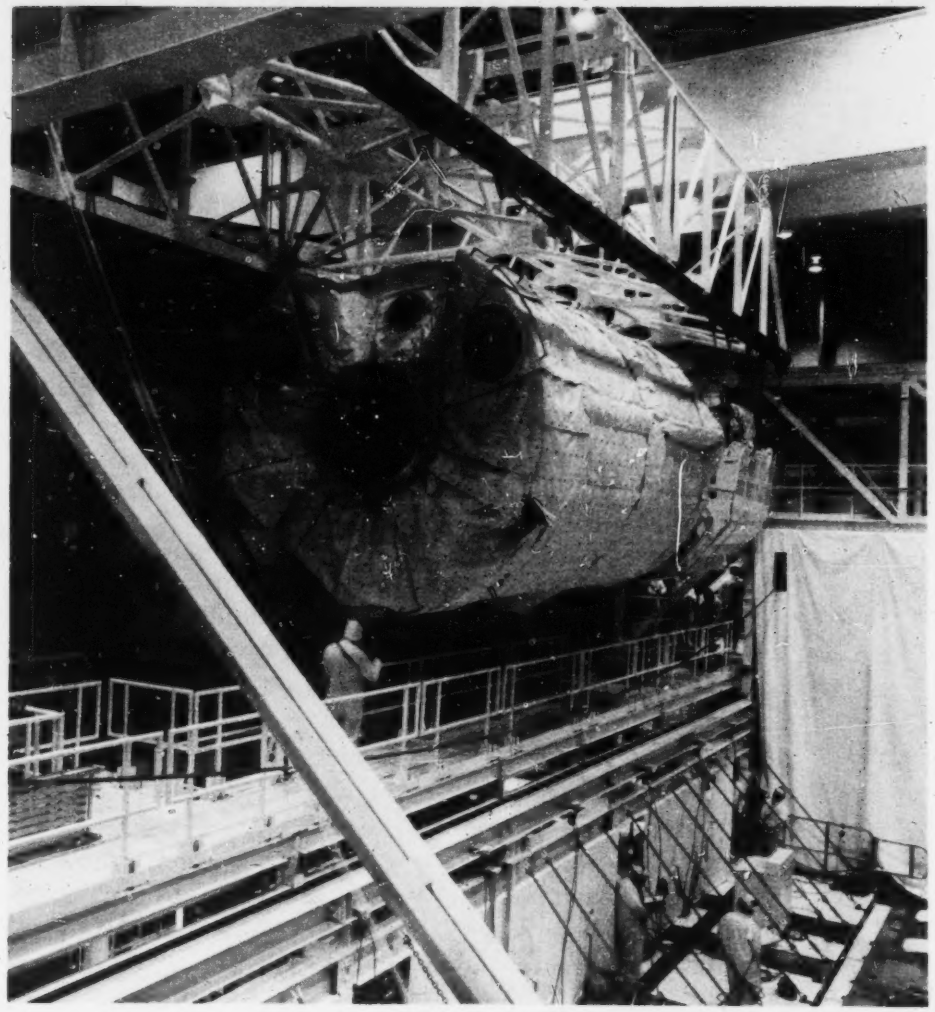

Photo credit: National Aeronautics and Space Administration

The European-built Spacelab-I module and attached pallet being prepared for installation in the cargo bay of the space shuttle orbiter Columbia, Aug. 16, 1983

phasis in export competition; instead it seems to be aiming to create a sizable space-related industry increasingly independent of U.S. technology and equipment. Although they now compete internationally only in electronics components and ground stations, **Japanese firms will be well positioned to become major competitors in international markets for space-related equipment and services by the early 1990s.** Under internal and U.S. pressures, Japan has recently opened its market to a limited degree to U.S. suppliers of satellites and telecommunications equipment.

Although the Soviet Union has the technological potential to compete with other countries for commercial services, space competition between the United States and the Soviet Union will continue to be more political

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and military than economic. Both nations today spend more on military than on civilian activities in space and make heavy use of space for purposes of geodesy, navigation, weather forecasting, reconnaissance, missile-launch warning, and communications. They are beginning to compete in developing weapons for use in space.

In space-related equipment and some service markets, international commercial competition outside of the European and Japanese markets occurs in countries like Brazil, India, and Australia, which desire to develop domestic satellite communications, and in INTELSAT and INMARSAT,* but the largest market where substantial open competition in sales of equipment takes place is the U.S. domestic market. U.S. firms continue to dominate both markets, although Japanese ground-equipment sales have been substantial in developing countries.

In satellite communications services, international competition is currently almost nonexistent, except to a limited extent in North America. Carriers typically must hand off communications at foreign borders or at the geostationary orbit, and are not allowed to sell full international services to consumers. In addition, INTELSAT has monopoly ownership of intercontinental satellite communications facilities, but major U.S. carriers and other firms are challenging this international regulatory management.

U.S. Private Sector Activities in Space

Some of the largest U.S. corporations are now heavily involved in space-related activities, especially satellite communications. Other firms are beginning to invest in developing their own space transportation, remote sensing, and materials processing systems. Many corporations derive significant revenues from producing specialized space-related equipment.

However, except for satellite communications, significant barriers of high cost and high technological and economic risk continue to deter investment. In space transportation and remote sensing, competition from U.S. Government-operated systems is a significant impediment. Nevertheless, fueled by technological advances and Government policy, the trend is toward more U.S. private investment in space systems. If current trends continue, there will be a wide array of privately financed space activities by the mid-1990s.

One continuing difficult task facing the U.S. Government will be to foster, in concert with the private sector, an efficient transition from the current preponderance of Government investment in civilian space activities to greater private sector investment in the 1990s. Such a transition occurred easily in satellite communications, because the demand for telecommunication services was already established and satellite circuits

*INTELSAT is a 108-country organization carrying two-thirds of the world's international communications. INMARSAT is a 37-country organization which was established in 1979 to facilitate maritime communications across the world's shipping lanes. COMSAT Corp. has been designated by the U.S. Government to serve as the U.S. representative to both organizations.

were an immediate cost-effective way to accomplish what was already being done on Earth. **In new technology sectors, with small and uncertain demand, and little institutional infrastructure, the process of transition is likely to be difficult and highly specific to the sector.** The process will require periodic attention from Congress. In these sectors, Government may be able to foster effective transitions by orienting its research and development (R&D) activities toward realistically evaluated market demand and by involving industry early in the process. One such strategy is the National Aeronautics and Space Administration's (NASA) Joint Endeavor Agreement (JEA), through which the private sector is encouraged to share costs with NASA on projects having significant research objectives and potential commercial application.

International Cooperative Activity

Space is by nature and treaty an international realm. The United States has played the leading role in international cooperative activities by sharing the fruits of its research with developing countries, assisting other industrialized nations develop their own space capabilities, and by helping to establish the international legal regime in space.

U.S. cooperative space projects continue to serve important political goals of supporting global economic growth and open access to information, and increasing U.S. prestige by expanding the visibility of U.S. technological accomplishments. U.S. noncommercial international space projects have been managed principally by NASA, and aided by the National Oceanic and Atmospheric Administration (NOAA) and the Agency for International Development (AID). These projects also support U.S. economic, scientific, and technological goals of obtaining access to countries for tracking stations and ground-receiving stations, influencing the space programs of other countries, and expanding research opportunities for U.S. scientists by sharing costs with other countries.

The examples of INTELSAT and INMARSAT, two commercially successful international cooperative organizations, illustrate that countries with political differences can cooperate to pursue common social, political, and economic goals in space. INTELSAT, in particular, by establishing new communications links and using advanced technology has served an expanding international market for telecommunications and services. It has been a large buyer of U.S. satellites.

Until recently, the United States had a virtual monopoly on the conduct of cooperative international programs in space (at least in the West). Now, in part because of the very success of U.S. efforts to involve the international community, other nations—especially Japan and some European nations—have developed their own bilateral cooperative programs. The Soviet Union continues to expand its international cooperative relationships in science and space applications. As a result of these circumstances, the United States is now one of several potential partners in cooperative space projects.

Developing countries will continue to depend on the United States and other industrialized nations for help in expanding their own capacity to use and develop space technology. **If the United States wishes to reap the full economic and political benefits of its space program, its cooperative applications programs must continue to involve the developing countries, especially because they are beginning to represent a significant market for space-related goods and services.**

The United States participates in various international organizations and meetings on space. Improved U.S. preparation for these international forums could result in more favorable treatment of U.S. interests and concerns. U.S. experience at UNISPACE '82[1] and the International Telecommunication Union (ITU) Plenipotentiary* demonstrated that such improvements will require long-term domestic policy goals for outer space; more effective coordination among U.S. agencies and the private sector; greater continuity of personnel; and recognition that our critics may also represent important future markets. The series of ITU meetings in the 1980s and 1990s, including ORB'85 on the geostationary orbit, will present occasions where U.S. policy will be tested.

SPACE APPLICATIONS

OTA examined a range of space technologies. Each is at a different stage of commercial development or Government operational status. Each therefore presents a different set of potential opportunities.

Space Transportation

The emergence of competition from foreign and U.S. private sellers of launch services requires a reassessment of the U.S. Government's traditional role as provider of launch services to commercial interests. The Government must examine whether and how it should continue to use the Shuttle in competing for foreign and domestic commercial launches.

The entry of ESA's Ariane booster into the international launch vehicle market brought an end to NASA's monopoly in providing space transportation services to commercial entities and foreign governments. Eventually Japan will also be able to offer competitive commercial launch services; still other nations are developing their own means to launch payloads. In some respects, national launch vehicle programs can be compared to national airlines: some are conducted primarily for profit, while others play a role which is clearly linked to perceptions of "prestige" and "national self-image." For these reasons, **U.S. competitive strategies based on price or superior technology alone will not prevent foreign entry into the launch services business.** Nations that possess the commitment and the minimum

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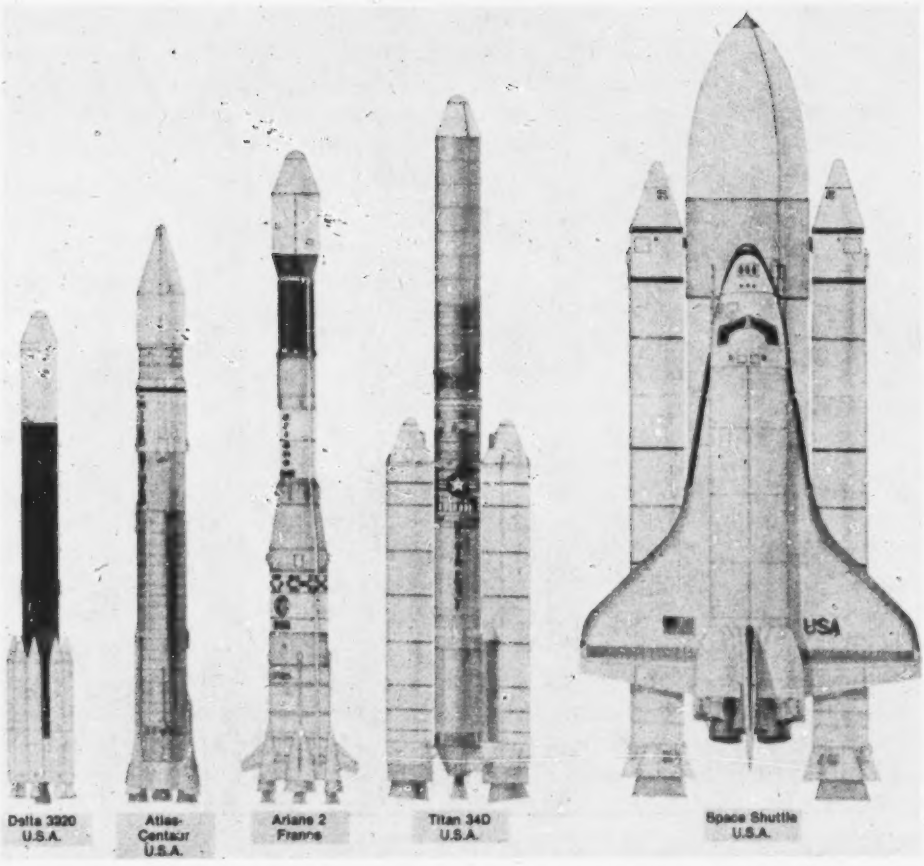
[1]See *UNISPACE '82: A Context for Cooperation and Competition* (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-TM-ISC-26, March 1983).

*The ITU Plenipotentiary Conference was held in Nairobi in September 1982. See hearings before the Subcommittee on International Operations of U.S. House Committee on Foreign Affairs, Feb. 22, 1983.



Current competition in space launching services from Earth to orbit is between these five launchers

SOURCE: National Aeronautics and Space Administration.

economic and technical resources necessary to develop launch systems will take some share of the total world market.

Although there are a number of potential entrants, launch service competition for the next decade is likely to be primarily between NASA, operating the Shuttle, and Arianespace, S.A., the French corporation* which markets the Ariane. **Both systems use technology developed by governments and compete primarily for the launch of large geosynchronous communication satellites. The Shuttle, although technically more sophisticated than the Ariane, has no special advantage in this market.** In addition, several U.S. private firms are competing in offering launch services.

A large percentage of potential launch business will undoubtedly be removed from international competition. For instance, with few exceptions,

*The French Government owns the majority share of Arianespace. The balance is owned by other European governments and some European aerospace firms.

neither the U.S. Government nor the Japanese or European governments are expected to make launch procurement decisions under competitive international bidding. Such restrictive trade practices could be altered by international agreement in the distant future; in the near future, however, it is unlikely that there will be effective coverage of launch services under either government-procurement or trade-in service agreements.

Much of the competitive part of the market will consist of private U.S. communications carriers putting up U.S. domestic satellites. INTELSAT, INMARSAT, and a few countries will also purchase satellite launching services competitively. Customers will base their choice on price (including the cost of financing), the reliability of launch and schedule, the relative ease of planning and processing payloads, the cost of insurance, and the availability of coproduction and other offsets. As with all large international contracts, political considerations will undoubtedly play a role.

The Administration policy on launch vehicle commercialization is ambiguous. On May 16, 1983, President Reagan announced that the U.S. Government fully endorsed and would facilitate the commercial operation of expendable launch vehicles (ELVs) by the private sector.* However, the President also stated that the Shuttle is the "primary launch vehicle of the U.S. Government" and that it would continue to be available for domestic and foreign commercial users. **The President's policy encourages "free market competition among the various systems and concepts within the U.S. private sector," yet leaves the Government-subsidized Shuttle as the main competitor to the private sector's efforts to market ELV services.**

Current Shuttle prices were developed to encourage users to transfer their business from the trusted ELVs, then operated by the Government, to the Shuttle. According to NASA, launch prices for the 1986-88 period will be based on the "out-of-pocket" costs, that is, those costs which a commercial payload adds to a mission on the assumption that it would otherwise fly partially empty when carrying a Government payload. **Current and projected pricing policies for commercial payloads allow the Shuttle to compete with Ariane's prices while earning some revenue and supporting other important national space goals; however, these policies decrease the probability that U.S. private firms will be economically successful in providing competitive launch services.**

The United States can meet the challenge of competitive foreign launch services by favoring either the Shuttle or private ELVs for commercial payloads. If the demand for launch services were to increase dramatically, both kinds of vehicles might successfully offer commercial launch services; but since a dramatic increase seems unlikely in the 1980s, the United States must choose which course it intends to follow.

Continuing to favor the Shuttle, by pricing policy or by other means, would reinforce its status as the centerpiece of the U.S. space program

*The Titan, the Atlas-Centaur and the Delta launch vehicles have all been the target of efforts to commercialize existing ELVs. Other smaller, private expendable launch vehicles are in development.

and support the pursuit of other long-term space goals such as building space stations, encouraging the development of manufacturing in space, and investigating new military space technologies. Such a decision would likely increase the cost to the taxpayer of the U.S. space program if it leads to additional subsidized Shuttle flights.

In order to spur the growth of an internationally competitive, private ELV industry, it would probably be necessary to limit the Shuttle primarily to Government launches or to increase the price of commercial Shuttle flights substantially. Additional support might be given to fledgling launch companies in the way of low-price access to Government launch facilities, assured launches (e.g., the Air Force's recent desire to purchase 10 ELVs), and a regulatory environment conducive to private investment.

Allowing commercial ELV firms to compete profitably might result in the emergence of a thriving, mature private space transportation industry in the United States by the 1990s. Because the Ariane and U.S. ELVs have comparable capabilities, such a decision might also allow the Government-subsidized Ariane to capture a larger portion of the international launch market than it would if it were competing against the subsidized Shuttle.*

Satellite Communications

Unlike other technologies discussed in this report, satellite communications technology has passed from Government-dominated investment to commercial status. Civilian satellite communications is now fully established within the overall telecommunications industry.

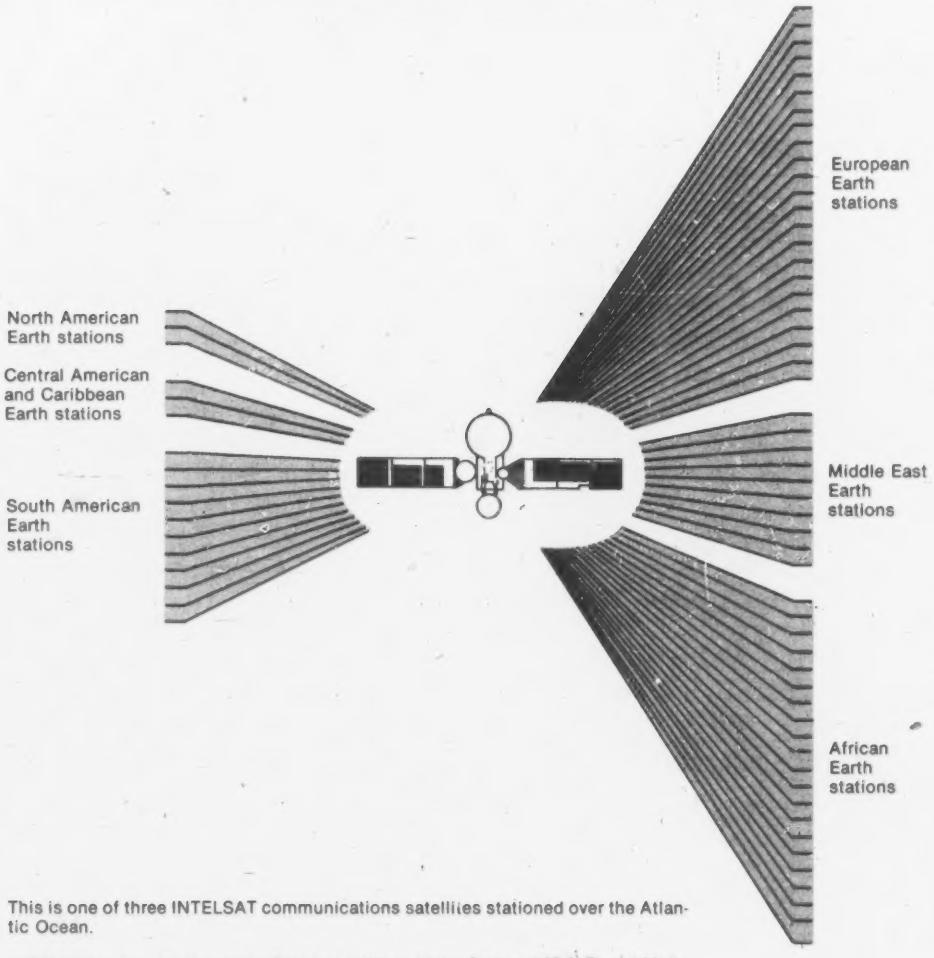
Competition in International Satellite Communication Services

In the United States, increasing numbers of satellite communications service providers, and types of services, have forced examination of the structure of the international satellite communications industry. In particular, several U.S. communications corporations have recently applied for authority from the Federal Communications Commission (FCC) to launch satellites to provide transatlantic satellite communications services. **The United States must soon decide whether it wishes to continue its past support of INTELSAT as the only provider of intercontinental satellite communications facilities** or whether it will permit U.S. firms to launch independent and/or competitive satellites.** Preventing U.S. firms from owning independent international satellite facilities would close off certain potentially profitable opportunities to them. But INTELSAT's monopoly status is strongly supported by many other governments. The United States

*Relatively powerful trade remedies for unfair foreign competition against U.S. goods and services are available to the Government. Recently, for example, Transpace Carriers, Inc., the company seeking to commercialize the Delta launcher, applied to the President to prohibit Arianespace from marketing its services in the United States and to penalize U.S. imports from the countries subsidizing Arianespace, S.A., under Section 301 of the Trade Act of 1974.

**Although all commercial intercontinental satellite traffic must pass through INTELSAT, regional systems provide limited international services in the regions they serve.

INTELSAT Atlantic Ocean Primary Satellite 335.5°E


European Earth stations
North American Earth stations
Central American and Caribbean Earth stations
South American Earth stations
Middle East Earth stations
African Earth stations

This is one of three INTELSAT communications satellites stationed over the Atlantic Ocean.

INTELSAT's two other Atlantic Ocean satellites, Major Path 1 (325.5°E) and Major Path 2 (341.5°E), have similar configurations.

must therefore weigh the interests of the U.S. private sector against other foreign policy objectives and existing international agreements.

The Government must also decide how vigorously to negotiate with other countries to advance the interests of its consumers and producers in other areas of international trade in satellite telecommunications services. Regulatory regimes in other countries prevent private carriers from competing freely in international communications service markets. Other nations typically require that communications reaching their territories be handled by their governmental telecommunications monopolies and accept traffic only from designated U.S. carriers in each market segment. Among the alternatives are: 1) bilateral negotiations with individual countries with the

short-term objective of access for additional U.S. carriers; and 2) longer term multilateral negotiations on a general GATT* code on trade-in services.

All of the foregoing has resulted in a situation where U.S. consumers have fewer price-service options in international than in domestic telecommunications markets. Moves toward freer international competition would be consistent with domestic steps toward deregulation and with recent U.S. efforts to secure fairer international trade.

Demand for Satellite Communications Services

Demand for all international telecommunications services is now probably increasing at 10 percent or more per year. **Within this, demand for satellite communications services is also increasing rapidly, but whether its growth will continue through the 1990s is highly uncertain. Satellite services will continue to dominate long-distance international communications at least until 1988, when the first transatlantic fiber-optic cable is scheduled for operation.** In the 1990s, annual growth in the demand for international satellite communications services could range from zero to a rate equal to the growth of international communications as a whole, depending on the relative shares of satellites and fiber-optic cables. The shares of satellites and cables will depend in turn on consumer preferences, business incentives, industry structure, and above all, on regulatory decisions. It is unlikely that the total demand for international satellite communications will decline during the 1990s.

Competition in Satellite Communications Equipment Market

U.S. satellite communications equipment firms continue to dominate the relatively open international markets, including the U.S. domestic market. However, access by U.S. producers of satellites and other satellite communications equipment to most industrial country markets is restricted by "buy national" policies on the part of post, telephone, and telegraph agencies (PTTs) or consortiums of PTTs, who are the primary purchasers of such equipment. Most governments purposely excluded their PTTs from coverage under the GATT code on government procurement, and thus multilateral trade remedies are not available.

Some bilateral progress has recently been made on opening up the Japanese communications satellite equipment market to U.S. suppliers, but European markets remain tightly protected. Meanwhile, deregulatory and antitrust actions in the U.S. domestic long-distance telecommunications market have opened up the U.S. equipment market to international competitors. Consequently, foreign communications equipment manufacturers have greater access to the U.S. market than U.S. sellers have to theirs.

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*General Agreement on Tariffs and Trade.

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Advanced R&D

Although some level of Government R&D funding may be necessary to maintain the competitiveness of the U.S. satellite communications equipment industry, Congress must determine how much is appropriate. Increasing congestion in the geostationary orbit over the Western Hemisphere for satellites using frequencies in the C-band (6/4 GHz) and Ku-band (14/12 GHz) may create a market opportunity for Ka-band (30/20 GHz) satellites in the 1990s. This opportunity, along with potential competition from foreign satellite system manufacturers, has led to the NASA Advanced Communications Technology Satellite (ACTS) program, which would develop a Ka-band system. ACTS components would be more advanced than Ka-band technology under development in Europe or Japan; some aspects of ACTS technology would also be applicable in satellites operating in the C- and Ku-bands.

Some satellites operating in the Ka-band may well be launched in the late 1980s. Hughes Aircraft Co. has already applied for permission to launch two. As planned, they would also be less advanced than the proposed ACTS system, but Hughes questions whether an ACTS-type system would be commercially viable. Depending on its perception of the threat of subsidized foreign competition and the capabilities of the U.S. private sector to meet it, Congress could: 1) continue to fund the full ACTS program through the flight testing stage, 2) fund only minimal communications satellite research, or 3) fund only that part of the ACTS research that can be carried out on the ground or in small-scale Shuttle experiments (on the assumption that the private sector will finance spacecraft tests of commercially viable innovations or that spacecraft tests could be postponed until foreign plans were clearer).

Participation in the International Telecommunication Union

Because most of the communications satellites over the Western Hemisphere belong to U.S. private firms or the Government, the United States has an interest in protecting the current method of allocating slots in this hemisphere's portion of the geosynchronous orbit. Slots are now registered by the International Telecommunication Union (ITU) according to a policy of "first-come, first served." However, many countries of Central and South America, along with other developing countries, espouse the principle of a priori allotments; whereby countries would be assigned slots in advance of actual need.

The ITU has called the 1985-88 World Administrative Radio Conference ("Space WARC") to consider international arrangements for planning and implementing the use of communications satellites in the geosynchronous orbit. (The particular meeting which will do so in 1985 is known as ORB'85.) **If the United States faced a limited allotment of geosynchronous slots, it would be obliged to deploy substitute capacity in the Ka-band or in fiber-optic cables, presumably incurring additional costs.** One such cost might be the premature obsolescence of certain C- and Ku-band ground

equipment. If C- and Ku-band slots had to be rented from countries to which they had been assigned a priori, such rents would also be an extra cost to U.S. consumers of satellite communications. Participation in ORB'85 will require careful planning and coordination among several U.S. Government agencies and the private sector. An isolated, combative stance in ORB'85 on the part of the United States against a priori planning could lead to difficulties in solving other international telecommunications issues. In particular, ill-considered U.S. actions that disrupted the ITU's decision-making processes could lead to changes in international arrangements for allocating and assigning frequencies to civilian and military communications in general.

Remote Sensing From Space

Land Remote Sensing[2]

The U.S. Landsat system is currently the only civilian land remote sensing system from which worldwide data are available. **By 1990, several other countries, including Canada, France, Japan, and perhaps the Soviet Union, expect to deploy competing systems to sense the oceans and the land.** France is treating its Systeme Probetoire d'Observation de la Terre (SPOT) as a commercial enterprise and has organized to market Earth resources data when the system becomes operational in 1985.

NASA developed the Landsat system and managed it as an R&D project until January 1983; Landsat is now managed by NOAA as a Government operational system. Landsat 5, launched in March 1984, is expected to be the last in the Government's Landsat series. Although NASA and NOAA will continue advanced research on new sensors and data processing techniques, using the Shuttle to test new methods, the Administration and Congress are now moving to transfer the operation of land remote sensing to the private sector.

Although the small size of the present market for Landsat data and consequent high economic risk* stand as major impediments to full commercialization, several private firms have expressed interest in providing land remote sensing data commercially. **Phased transfer to private hands, in which a designated private firm uses its commercial skills to develop a market for Landsat data, may result in an overall market for data and services adequate to support both a self-sufficient land remote sensing business and the entrance of more than one data seller.****

Without sufficient oversight, transfer of land remote sensing to the private sector would negatively affect our relationships with other nations. In view of the continued importance of the "open skies" principle to the United States, recent legislation*** continues the policy of nondiscrimi-

[2]See also *Remote Sensing and the Private Sector: Issues for Discussion,* (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-TM-ISC-20, March 1984).

*The current annual market for Landsat data is about $10 million. Satellite capital costs (for a 5-year lifetime) are likely to be greater than $100 million.

**H.R. 5155, passed by Congress June 28, 1984, provides for a phased transfer.

***H.R. 5155

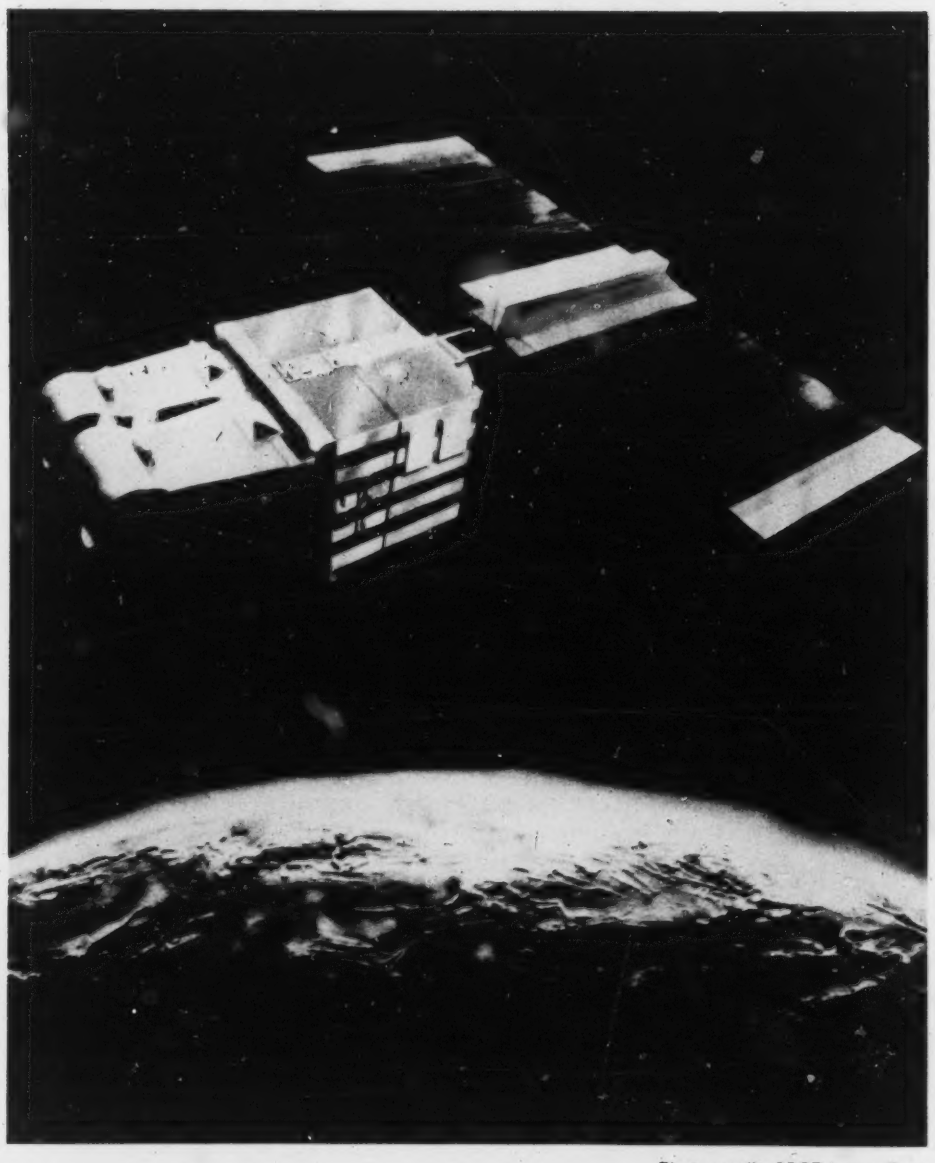

Photo credit: SPOT Image Corp.

Artist's conception of the French SPOT remote sensing satellite. Property of CNES, France

natory sales of land remote sensing data. Not to do so would be harmful to many U.S. foreign policy interests, not just those involving outer space. Because the first commercial U.S. land remote sensing data supplier will have a near monopoly position, it may also be appropriate to restrict it from entering into the value-added business* until a competitive interna-

*Value-added remote sensing corporations process and manipulate remote sensing data to increase their value to the end user.

tional remote sensing industry develops. Developing country buyers may otherwise realistically fear that there may be discriminatory access to data.

Lack of dependability of data delivery continues to be the single most important concern of current and potential domestic and international customers of remotely sensed data from space. The lengthy debate over the Landsat program has caused both domestic and foreign customers to limit their investment in land remote sensing hardware and services. Such limitation of investment, in turn, has impeded the development of international markets for Landsat-derived products. **Building a substantial market for remote-sensing data will likely require sizable subsidy for a period of years. It will also require system improvements that lead to low-cost data products, and a strong value-added industry.** It will be especially important for the Government to avoid competing with value-added firms.

Remote sensing data services are part of the information industry; interpretation and integration of these data with other data require extensive use of information technology. **Successful commercialization of Earth resources space-related systems is therefore directly dependent on advances in information technology that will make data manipulation, storage, and retrieval simpler and less expensive.** In particular, as microcomputers become more powerful, and as appropriate computer software is developed, even relatively unsophisticated users may eventually become purchasers of Earth resources data products—if their prices become sufficiently low.

The pressure for international agreements requiring "prior consent" to acquire remotely sensed data from another country will continue to mount as spatial and spectral resolution improve. However, if a strong, open, competitive market for data products and data services develops, such pressure is likely to diminish.

Meteorological Satellites (Metsats)

Public Law 98-166 prevents the sale or transfer of U.S. metsat systems to private industry and requires that they be operated in the public interest. At present, the commercial value-added market for weather data from satellites is extremely small. However, **innovative applications of metsat data to agriculture and hydrology demonstrate that, when properly processed and integrated with other data, they can sometimes substitute effectively for moderate resolution land remote sensing data.** Because metsat data have the advantage that they are sensed and delivered twice daily, their use for these purposes may reduce the market for higher resolution, Earth resources data.

As meteorological satellite systems have grown sophisticated and consequently more complicated, costs of building and operating the systems have also grown. In contributing to the continuity of international collection and analysis of environmental data, the United States could follow one of the following policy options: 1) It could continue to operate two civilian polar orbiters and two geostationary satellites and share data in-

Photo credit: National Oceanic and Atmospheric Administration

Six-day normalized vegetative index composite made with data from instruments aboard the NOAA-N series polar orbiter

ternationally. 2) It could operate only one polar orbiter. Reducing polar-orbiter service would likely save roughly $25 million per year, but would lead to reduced service to Hawaii and Alaska as well as to the U.S. military. It would also reduce our ability to share metsat data with other nations. 3) Alternatively, the United States could join with other industrialized nations in a joint international system, as the Administration has proposed. The United States could save money on building and operating meteorological satellites *and* demonstrate its leadership in developing space for peaceful purposes by joining with other nations to build and operate such a system.

Photo credit: European Space Agency

Visible wavelength image of weather patterns on Earth, as taken by Meteosat, the European geostationary meteorological satellite. Meteosat was developed and built by the European Space Agency

Ocean Remote Sensing

NASA's experimental Seasat ocean remote sensing satellite demonstrated in 1978 the utility of collecting data on properites of the ocean from space. Although no U.S. civilian system is now foreseen, the U.S. Navy is planning an operational ocean remote sensing satellite (Navy Remote Ocean Sensing Satellite—NROSS) for launch in 1988 or 1989. NOAA will collect and distribute data from NROSS. Canada, ESA, and Japan all expect to have operational civilian ocean remote sensing systems in the late 1980s or early 1990s. None of the systems by themselves will produce the full range of

useful ocean data. **If all parties were willing to coordinate satellite orbits and to supply their data in usable form, NOAA could play a crucial role in collecting, organizing, and distributing data from the U.S. Navy and the foreign ocean remote sensing systems.** Alternatively, at some time in the future, it may be desirable to develop an international ocean remote sensing system.

Remote Sensing in Developing Countries

Most developing countries lack the basic infrastructure to use Earth remote sensing data efficiently. Because the meteorological terminals are relatively inexpensive to install and operate, **gaining experience with receiving and processing weather data may be the best way for developing countries to build the infrastructure necessary to utilize remotely sensed land or ocean data.** At the same time, advances in information technology that will make it easier and cheaper to process remotely sensed data will vastly improve the ability of the developing countries to use them. By continuing to support remote sensing programs in developing countries, the United States could help these countries develop their own resources and stimulate the international market for land remote sensing data products.

Materials Processing in Space (MPS)

There is no international commercial competition in MPS because commercially significant MPS products have yet to be developed; governments are now responsible for most MPS research activities. Given the cost and complexity of research in space, and the limited understanding of space processing and its supporting technology, international cooperation in MPS research could contribute substantially to long-term U.S. objectives in space. A few firms, working with NASA, are studying specific processes which could result in commercial products.

The primary motivation for studying the properties of materials in space is to use a microgravity environment for extended periods for scientific and, perhaps, commercial applications. Operating in a near zero-gravity environment may lead to improvements in controlling process variables such as temperature, composition, and fluid flow, and afford opportunities for understanding and improving ground-based production methods. Where economical, it might eventually lead to manufacturing selected products in space.

Should MPS products prove to be commercially viable, the United States would eventually face market competition from other nations who are also gathering experience in microgravity research.* Most foreign MPS activities have been conducted by ESA under the primary sponsorship of West Germany. European MPS activities include an active sounding rocket program, the development and use of Spacelab and related hardware, and

*Foreign ability to compete in space manufacturing will depend strongly on availability of the Shuttle to foreign users or on the development of suitable foreign launch vehicles and carriers.

the development of the reusable free-flying platforms, SPAS and EURECA. As a result of these activities, Europe will likely become an important source of information on the behavior of materials in microgravity. Japan has a small but active sounding rocket program directed toward MPS research; it has also used the Shuttle and Spacelab to carry out experiments. The Soviet Union has done a considerable amount of MPS research in its Salyut space station, but this research is unlikely to result in commercial competition for the United States.

At present, U.S. commitment to the Shuttle and to the development of an MPS science community, as well as NASA's encouragement of certain commercial space activities, have given U.S. industry a technological advantage. This advantage could diminish over the next decade as foreign access to space becomes more routine and the advantages and limitations of microgravity technology become more widely known.

MPS research and hardware development in Europe and Japan, in addition to raising the potential for future commercial competition, have made these countries valuable partners for international cooperation. Considering the current limited understanding of MPS and the high cost of investigating this technology, international cooperative activities would offer the benefit of expanding the base of knowledge while sharing costs. The United States should encourage international cooperation in basic scientific investigations or in areas in which the United States can benefit from foreign research (e.g., basic biomedical research and research in solidification). It should proceed cautiously in areas that might have near-term commercial applications or in which the United States holds a clear technological lead (e.g., continuous flow electrophoresis and containerless processing).

Any decision to increase Government support for MPS research should probably include increases in funding for international cooperative activities such as formal and informal exchanges of scientific personnel and information, and sharing of facilities such as the Shuttle, Spacelab, and European- and Japanese-built hardware. **Joint research projects such as the International Microgravity Lab proposed by NASA, which would allow the cooperative use of the Shuttle and foreign MPS hardware, seem to offer significant benefits and savings to NASA and the U.S. taxpayer.**

It is impossible to predict the future size or vitality of the markets for MPS products, services, and equipment. Although in the near-term, a few commercial MPS products will be developed, the long-term potential of microgravity research will not be known until substantially more research has been accomplished. The potential for developing a U.S. MPS industry depends on: continued Government-funded basic research; the availability of reliable, low-cost space transportation; and access to medium- or long-term MPS facilities such as free-flyers or a space station. It depends most on the discovery of commercially viable MPS products.*

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*McDonnell Douglas and Johnson & Johnson have been working since 1977 on processes to develop marketable pharmaceuticals. They hope to market their first product manufactured in space by 1987.

Cooperation

Cooperation between countries in space science continues to be a major source of cultural, economic, political, and social benefits. Cooperation occurs in a variety of modes—among individuals, institutions, and governments. The Infrared Astronomical Satellite (IRAS), by which several major astronomical discoveries were made recently, is an excellent example of the high level of science that cooperative ventures can achieve.

Exploratory missions in astronomy and planetary science are increasingly complex and expensive. Although political considerations are important, the major driving force behind large cooperative space science projects will continue to be the prospect of sharing costs. Yet the complexity of such missions makes joint management by different governments, space agencies, and research institutions difficult. For this reason, international cooperative missions in which costs are shared should be designed so as to keep the management as simple as possible.

Now that ESA and Japan are able to mount major interplanetary missions, the terms of international cooperation have changed. In the International Halley Watch, for example, the United States has assumed a supportive, rather than a leading, role. **This change from its accustomed role reflects a recognition that the United States need no longer rely solely on unilateral efforts to maintain momentum in space science generally. The United States can now anticipate some return on our earlier investments in the space science programs of our cooperative partners.**

Whatever part the United States assumes in cooperative space science activities, it is extremely important for the United States to adhere to its cooperative agreements. As a case in point, the U.S. decision in 1981 to reduce substantially its participation in the International Solar Polar Mission continues to be named as an example of the difficulties involved in cooperating with the United States.

Competition

It is difficult to speak of direct competition in space science, at least among Western nations, as every nation's plans are known well in advance and there is little to be gained from duplicated research. (This was part of the reasoning behind the U.S. decision not to send a spacecraft to Halley's Comet.) Relative prestige is primarily a function of previous accomplishments and available resources.

Space science is also one way in which the United States demonstrates its leadership in space technology. **Although the United States maintains a leadership position in space science, as other nations gain greater experience, the United States faces increased competition in certain subfields of space science from ESA, Japan, and the Soviet Union.** One way in which the United States can maintain its broad base of knowledge and technology, while minimizing costs, is to continue to cooperate with other

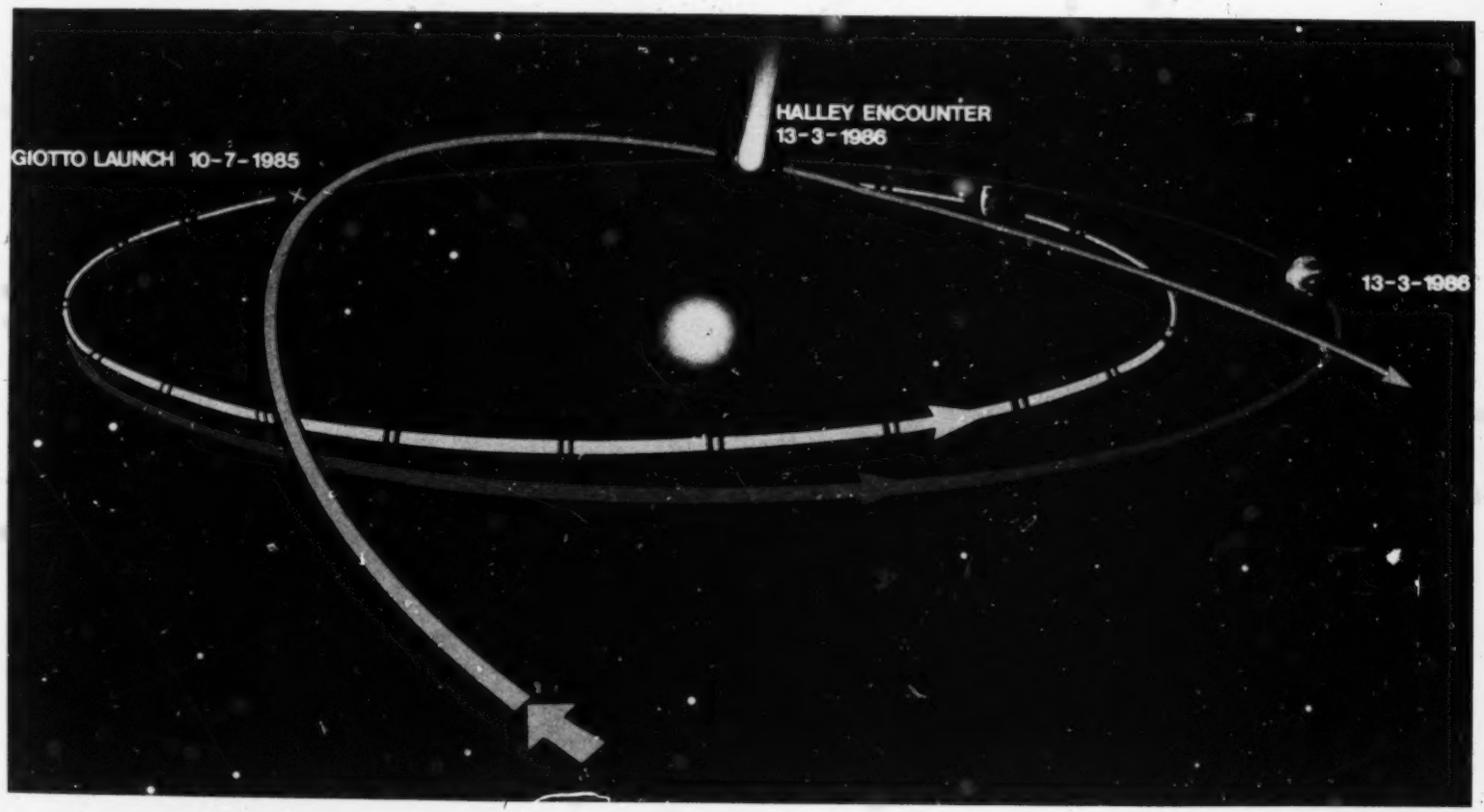

Photo credit: European Space Agency

The European Space Agency's Giotto comet probe is expected to pass within 100 to 500 kilometers of Halley's Comet. Data from the Soviet Vega probes to Venus, gathered and processed by NASA, will help to guide Giotto to a rendezvous with the comet

countries, and to be aggressive in proposing experiments for foreign spacecraft.

Another competitive aspect of space science, and one which is fairly new, is the competition for cooperative partners on scientific missions. The Soviet Union has used such cooperation as a way to branch out from its Intercosmos base of Soviet bloc countries, to extend its influence, and to acquire needed scientific/technological expertise. The recent flight of an Indian cosmonaut aboard the Salyut 7 space station is one example. The Soviets are continuing an elaborate program of joint scientific projects with France. The United States must not overlook this competitive factor with regard to Third World interest in space science as a means of building the infrastructure necessary for space applications. **In the long run, the United States must remain cooperative in space science in order to remain competitive.**

The international market for space science equipment and services is relatively small. Because the United States has a well-developed infrastructure for supplying this market, it will continue to dominate the market for the foreseeable future.

U.S. CIVILIAN SPACE POLICY

Analysis of the issues raised by this assessment reveals that **two major problems dominate the organization and implementation of U.S. civilian policies toward space: 1) there is no national consensus about long-term goals and objectives in space, and 2) the political and economic dimension of space activities now exceed the purview of any one Government agency.**

Future Goals and Objectives

To maintain focus on the Nation's goals in space, periodic high-level review and discussion are required. In recent years, the Administration's examination of space policy has centered in special committees organized within the White House, and has been dominated by military and national security, as well as yearly budgetary, concerns. The current Administration's space policy committee, the Senior Interagency Group for Space (SIG-space) reflects this emphasis.* Neither the private sector nor several agencies** with long-standing responsibilities in the U.S. civilian space program are represented.

Observers generally agree that the United States needs to establish new specific civilian space goals. One possible mechanism for encouraging a national debate over the U.S. future in space is the National Commission on Space, as authorized in H.R. 5154.*** A National Commission on Space

*The Senior Interagency Group is composed of representatives from the Departments of Commerce, Defense, and State, and the Central Intelligence Agency, the Joint Chiefs of Staff, the Arms Control and Disarmament Agency, and NASA.

**For example the Departments of Agriculture and Interior, the National Science Foundation, FCC, and AID.

***Passed by Congress, June 28, 1984.

could, among other things, provide a public forum for analyzing the needs of the Nation with respect to space. It could also help to develop a national consensus on new long-term goals and objectives.*

Given the widespread and expanding uses of space, the diversity of governmental and private users, and the increase in international commercial competition, a commission designed to recommend future policy should be as diverse and as broadly based as possible, and include members from the private sector. **The Commission should seek input from all the Government agencies with responsibilities in space, but remain independent of them.** In addition to recommending goals and objectives, the Commission should provide guidance for implementing its recommendations in the context of other national goals.

It will be important for the Commission to specify the relationship of new goals and objectives to other national goals, and to take account of the limitations, as well as the strengths, of space policy. Just as satellite communications have become integrated into the telecommunications industry, **so will other space technologies, as they mature, become integral parts of larger, nonspace industries. They will then gradually become less appropriate objects of space policy, and more appropriate objects of policies related to those industrial sectors they serve.**

It is inappropriate to use space policy (which provides direction about the future exploration and exploitation of space), for example, to make decisions on international trade in space-related goods and services in isolation from the U.S. Trade Representative, decide on the requirements of international satellite telecommunications in isolation from the FCC, or to plan international programs in isolation from the Department of State. Nor should space policy per se be used to guide the overall planning of operational Government systems. For example, as the long debate over the Landsat program has demonstrated, systems that are expected eventually to provide continuing services should be planned primarily by those who will be expected to provide the technology, and use and pay for services.

Organizing for Space Activities

In the past, what this Nation sought to accomplish in space was achieved by NASA within the broad principles and goals of the 1958 National Aeronautics and Space Act (NAS Act). Today, the increase in foreign and commercial activities means that other Government agencies (not mentioned in the NAS Act) now play a greater role in space. Already, the Departments of Agriculture, Commerce, Interior, and State, and the FCC, in conjunction with the private sector, manage most of the civilian applications of space technology. Recently the Department of Transportation (DOT) has been charged with promoting and regulating private sector space transportation systems.** **Strengthening U.S. competition with other**

*For an initial suggested list of such goals and objectives, see *Civilian Space Stations* (Washington, DC: U.S. Congress, Office of Technology Assessment, in press.)

**This assignment was made by President Reagan, Congress is now considering DOT's role in space transportation.

space-capable nations, or improving our ability to cooperate effectively, will require careful attention to the means of coordinating the activities of all of the Federal agencies with an interest in space with each other and with those of the private sector.

For example, this year's authorization legislation for NASA, H.R. 5154, amends the NAS Act to include a provision directly related to private sector activity in space:

> The Congress declares that the general welfare of the United States requires that the National Aeronautics and Space Administration seek and encourage, to the maximum extent possible, the fullest commercial use of space.

This provision directs NASA to involve itself in the commercial exploitation of space. **Yet NASA, by itself, is not well-equipped either to choose specific technologies for commercial exploitation or to foster the creation of new space industries.**

Seeking the fullest commercial use of space will require the direct involvement of those agencies versed in domestic commerce and regulation, international trade, and foreign affairs. **Government decisions regarding commercial space activities must above all be responsive to how the actual markets and industries involved work, and how international competition in space industries relates to international competition generally.**

In order to foster effective coordination, it will be important for Congress to designate clearly a lead agency for regulating a particular private sector activity. As new specific commercial space technologies mature, agencies other than NASA should be given primary responsibility for their oversight. The recent designation of DOT as the lead agency for private space transportation services indicates how the responsibilities for overseeing commercial space activities could be organized in the future.

The ability to pursue foreign policy objectives through cooperative space activities is hampered by the fact that no single agency has control over U.S. cooperative activities. Currently, the responsibility for cooperative international civilian space activities is divided among the Department of State, Department of Commerce, FCC, and NASA. The conduct of foreign policy is the responsibility of the Department of State, which has little expertise in space. If the United States wishes to use its civilian space activities to pursue U.S. foreign policy interests more aggressively, it will be important to expand the Department of State's space expertise.

Cooperation and Competition as Part of Policy

Cooperation and competition with other nations are not ends in themselves; they are merely tools with which to carry out long-term national security, political, and economic objectives. Nations have cooperated for humanitarian reasons, for example, in the U.S. Advanced Telecommunications Satellite experiments of the 1970s or the current U.S., Canadian, French, and Soviet Sarsat project. They have also cooperated to obtain technology or resources which would later allow them to compete economi-

cally or politically. Examples of this include ESA's work with the United States on Spacelab and NASA's cooperative programs involving remote sensing. European competition with the United States in launch services and remote sensing has helped to establish Europe as an important partner for cooperation with other nations.

If the United States wishes to retain an international leadership role in the continued exploration, development, and use of space it must be effective at both cooperation and competition. A clear understanding of long-term national goals and objectives and a workable division of responsibilities and coordination among the various Federal agencies as well as between Government and the private sector will therefore be essential.

NOTE: Copies of the full report "International Cooperation and Competition in Civilian Space Activities" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

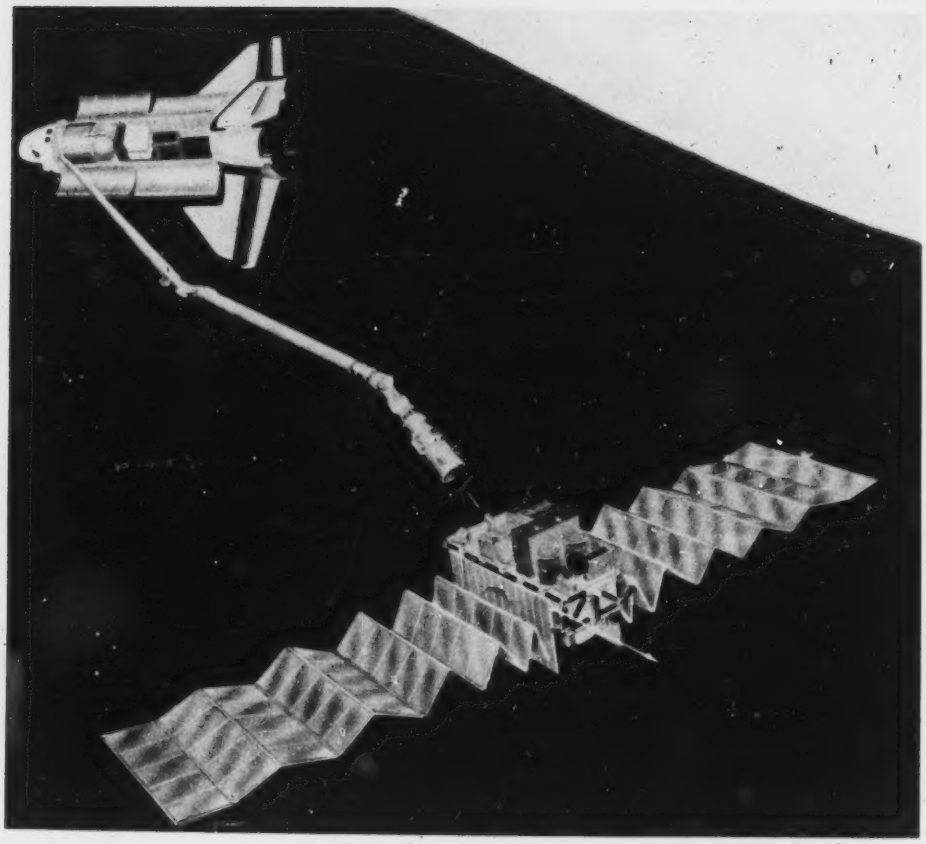

Photo credit: European Space Agency

Artist's view of the European-developed EURECA space carrier being deployed from the U.S. Space Shuttle with the Canadian-built remote manipulator arm

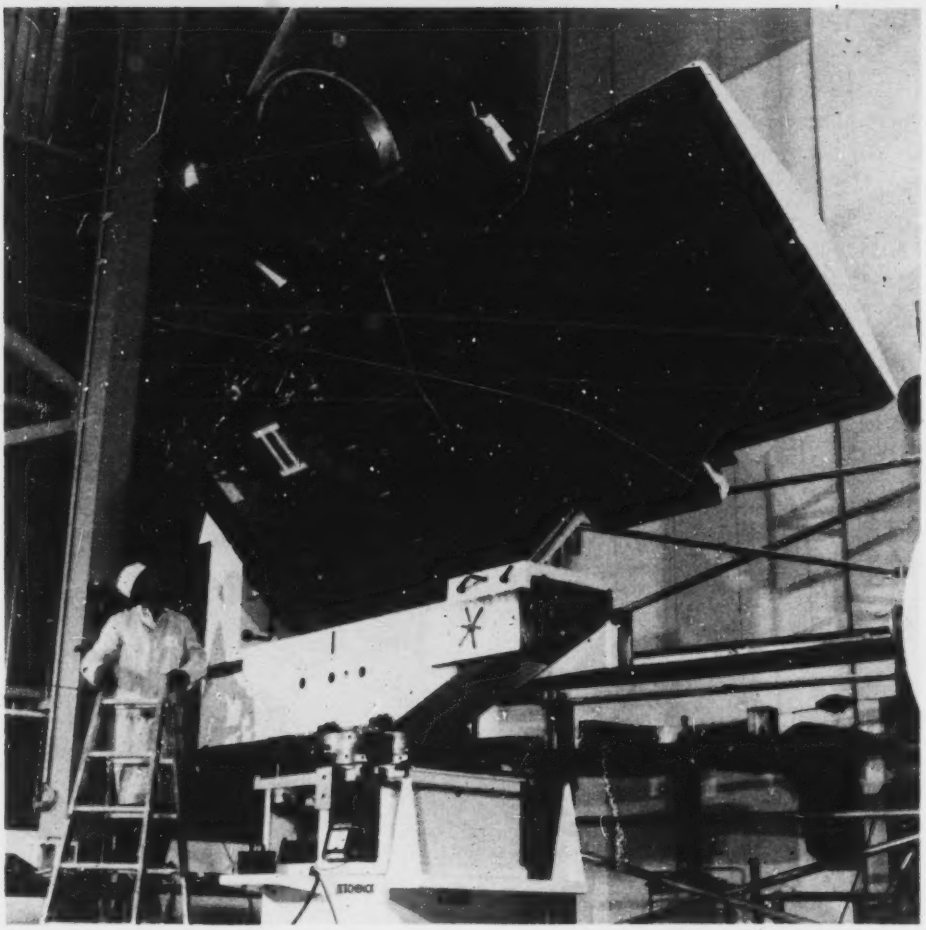

Photo credit: European Space Agency

The ESA EXOSAT satellite undergoing tests. EXOSAT has observed a number of X-ray emitting sources in the Milky Way galaxy and beyond

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JULY 1984

International Cooperation and Competition in Civilian Space Activities (insert to executive summary)

The executive summary of this report was published as a separate document in July 1984. The report was published in July 1985, and its chapters are up to date as of May 1, 1985. Since July 1984, several issues identified in the summary as needing policy attention have been addressed by Congress and the Administration, at least in part. This page updates the original summary.

International Cooperative Activities (p. 11)

The United States has signed agreements with Canada, Japan, and ESA to cooperate in the design phase (phase B) of NASA's space station program. Each country will assume its own costs for this and subsequent phases. **The terms of cooperation in the international development and operation of elements of permanent space infrastructure will require careful attention by Congress to ensure that the United States achieves its goals in international cooperation.**

Space Transportation (p. 12)

On October 30, 1984, the Commercial Space Launch Act (Public Law 98-575) was signed into law. It was designed, among other things, to "encourage the United States' private sector to provide launch vehicles and associated services by simplifying . . . the issuance . . . of commercial launch licenses and by facilitating . . . the utilization of Government-developed space technology . . ." The Act does not attempt to resolve the problems caused by competition between the Shuttle and private ELVs. Congress and the Administration are grappling with, but have not resolved, the difficult issue of Shuttle pricing.

Recently the Administration decided against further consideration of transferring the management of Shuttle operations to the private sector, among other reasons, on grounds that the Shuttle is an important instrument of national policy and is needed primarily for Government civilian and military payloads.

In 1984 the Air Force awarded contracts to both General Dynamics and Martin Marietta to study advanced launchers based, respectively, on the Atlas and the Titan. The Air Force declared the Titan-derivative the victor in this initial competition. In a second round, undertaken to include NASA, the Air Force recommended the Titan-derivative over the NASA-proposed SRB-X, an ELV based on Shuttle hardware.

Satellite Communications (pp. 16 and 18)

In November 1984, the Administration endorsed U.S. private transatlantic satellite systems as "required" in the national interest but it also circumscribed their ability to compete with INTELSAT. The matter is currently the subject of a proceeding at the Federal Communications Commission (FCC). It is not yet clear how vigorously the Administration might support private U.S. applicants, nor what competing foreign commercial systems may be proposed. The INTELSAT Assembly of Parties meeting in January 1985 coordinated a significant additional number of U.S. and Canadian satellites offering limited transborder satellite services for the developing Western Hemisphere regional system of independent satellite operators. Most of these services have now received final FCC approval.

84-J952-30

Probably the most significant recent event for international satellite communications has been the conditional approval by the FCC, outside the North Atlantic Consultative Process, of a very high capacity, British/American fiber optic cable facility. The Secretary of State has yet to act on the FCC recommendation that he approve the facility. This and other planned facilities could lead to vast overcapacity in transatlantic telecommunications in the mid-1990s. This FCC action seems to presage changes in the traditional international regulatory structure for telecommunications.

Land Remote Sensing (p. 25)

Beginning in September 1984, the Department of Commerce attempted to negotiate a contract with EOSAT Corp.[1] according to the terms of the Landsat Commercialization Act of 1984. EOSAT, Commerce, and OMB have reached agreement (in May 1985) over the amount of the subsidy ($250 million plus launch costs) and EOSAT's financial risk. It will now be up to Congress to appropriate the transfer funds. Should the experiment in commercializing land remote sensing eventually fail, Congress will be faced with a decision about the future of land remote sensing from space. It could then: 1) decide to reestablish Government ownership of the system, 2) attempt to establish an international land remote sensing system where costs could be shared, or 3) cease to fund land remote sensing altogether.

Although Public Law 98-365 calls for continued R&D on remote sensors and applications techniques, in August 1984, NASA reduced its support for near-term R&D on land remote sensors. NOAA devotes less than $1 million yearly to applications research (for land remote sensing). In contrast, other nations are increasing their investment in remote sensing R&D.

Meteorological Remote Sensing (p. 27)

In November 1984, the United States reached agreement with Canada, France, and the Soviet Union to make the COSPAS/SARSAT search and rescue program operational by carrying SARSAT receivers on two polar-orbiting metsats. This agreement continues, but does not guarantee, a two polar-orbiting system.

Future Goals and Objectives

On March 19, 1985, President Reagan announced the appointment of commissioners to the National Space Commission. Their term is to last 1 year. In view of the desirability of continuing a national discussion of U.S. space policy, it may be appropriate to extend the term of the Commission beyond 1 year.

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[1] A corporation started by RCA and Hughes Aircraft Corp. specifically to market Landsat data and to construct, own, and operate follow-on Landsat satellites.